EMCAL Electronics Design Considerations

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This document is a summary of design considerations and criteria for upgrading the readout electronics for the Electromagnetic Calorimeter in the E-907 MIPP experiment.
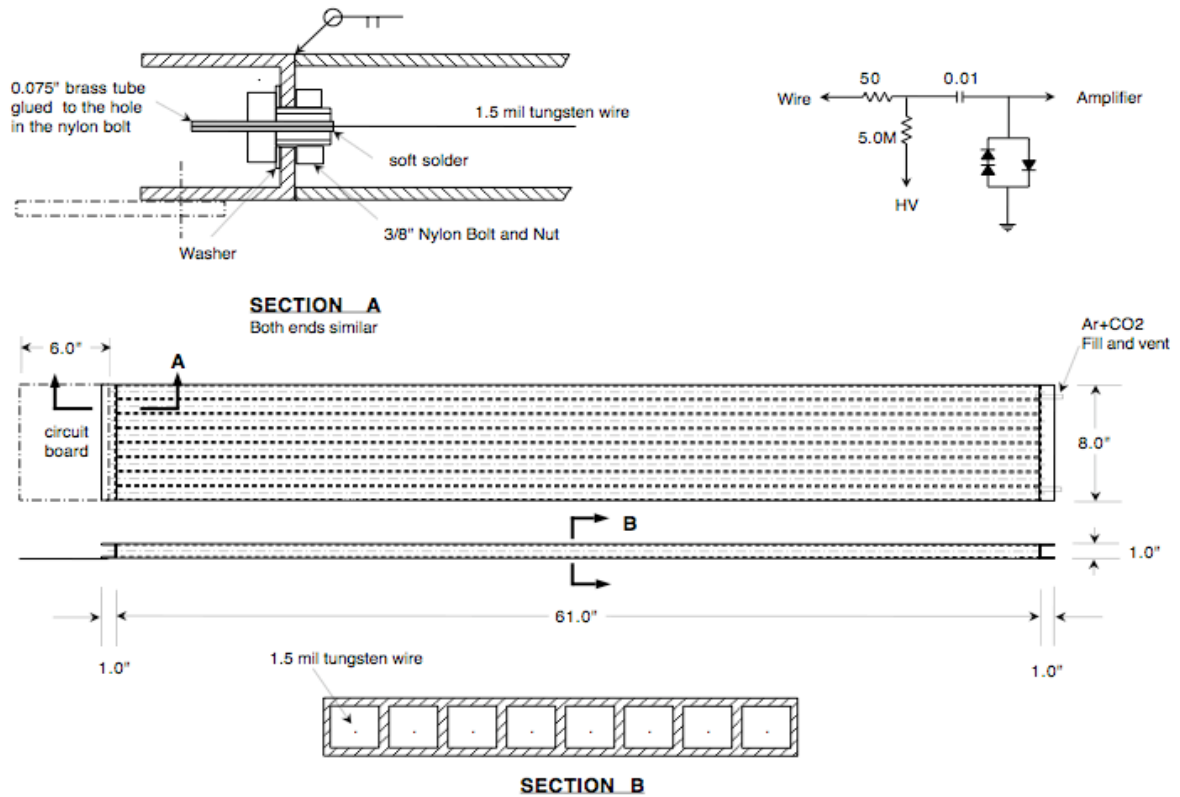
Overview

The MIPP EMCAL is made up of 10 sheets of lead alternating with wire chamber planes. The planes are mounted on a unistrut support frame in MC7. Each wire chamber plane has 64 wires made up out of 8 modules with 8 wires each. There are presently a total of 20 32-channel amplifier boards that amplify, delay, and multiplex the analog signals. These are then digitized by 4 plane-controllers with 12-bit ADCs and interfaced with a CAMAC module. The pulse heights from the wires are used to identify showers in the EMCAL and measure their energies and locations.

High-Voltage

The HV and signal connections to and from each chamber are done on a G10 "HV board" 8"x6" screwed on to the ends of the chambers. A sketch of a chamber and the circuit diagram of an HV board are shown in Figure 1. The HV lines on the chambers are connected together and the grounds of the HV boards are taped together with copper foil. A Droege Positive HV supply powers each EMCAL plane and the planes are all operated at the same voltage, approx. 2300V.

The HV board has an HV decoupling capacitor, a 50 Ω series resistor, and diodes for each wire to protect the amplifier against sparks in the chamber. The board also has sockets for mating with the male pins on an amplifier board. The original version of the amplifier boards ("8-channel boards") attached to the HV circuit boards directly. However, the version of the amplifier boards used in MIPP handles 32 channels and is connected to the HV boards by twisted pair cables. Note that these cables were prime suspects for causing noise and oscillations in the previous run.

In designing new electronics, we would like to have it attach to the HV board directly and do away with the cables.

0.075" brass tube
glued to the hole
in the nylon bolt

1.5 mil tungsten wire

soft solder

Washer

3/8" Nylon Bolt and Nut

SECTION A
Both ends similar

6.0"

A

circuit
board

B

61.0"

1.0"

1.5 mil tungsten wire

1.0"

50   0.01

Wire

5.0M

HV

Amplifier

Ar+CO2
Fill and vent

8.0"

1.0"

1.0"

SECTION B

Amplifiers and Digitizers

Each amplifier board now handles 32 wires. The input is via twisted pair cables from four HV boards. As mentioned above, the earlier version of the amplifier boards handled only 8 channels [equivalent to one module] and mated directly with an HV board at the chamber end. One other difference between the 8-channel and the 32-channel versions is in the way the delays are handled. In the 8-channel board, the pulse from the charge-integrating amplifier was made to have a long rise-time whereas in the current 32-channel board, there are individual analog delay lines (approx. 400 ns) for each channel. These delays were necessary to allow time to form a trigger and get it back to the readout.

 The multiplexed output analog pulses are sent to the "plane-controllers" for digitization via 20-conductor flat ribbon cables. If a trigger was received, the plane controllers started to digitize 160 channels sequentially. The digitization is done by an AD774 ADC in each controller. The 4 controllers for the detector were daisy-chained and interfaced with a CAMAC module.

Design considerations for the amplifiers and digitizers:

1. To avoid issues with noise and oscillations arising from the input cables, it would be preferable to have the preamp board mounted directly on the HV board.

2. Currently, a minimum ionizing muon is approx. 50 counts above pedestal. This corresponds to a charge of 0.04 pC [2.5e5 electrons] from a wire. We would like to keep the noise to < 6% of this. In other words, < 1.5e4 electron equivalents.

3. The ADCs used in MIPP are 12-bit. It is important to keep them at least 12-bit in order to (a) maximize dynamic range, and (b) allow detection of a single minimum ionizing particle (MIP). Currently, the pedestal is at approx. channel 90, and the minimum ionizing signal is 50 counts above pedestal. This implies a dynamic range of about 80 MIPs where the 12-bit ADC reaches full scale. In the upgraded system, we want to keep the dynamic range to be from 1 MIP at the low end and at least 100 MIPs at the high end. This means the new ADC should be 12-bit or equivalent to allow for separation of a single muon from the pedestal and at the same time allow for 100 MIPs in one wire. [In a 10-bit ADC, the pedestal would have to be at channel 1, a muon at channel 10 and 100 MIPs at channel 1000 which is not acceptable.] If we are restricted to <= 10-bit ADCs and still wish to preserve dynamic range, one option could be to have, for example, 2 8-bit ADCs – one "fine" for small pulses, and the other "coarse" for large pulses. The "coarse" one would be used when the "fine" ADC saturates. Note: The ADCs for the HCAL are 14-bit. The HCAL readout is however quite fast and is more than capable of the expected trigger rate.

4. We currently have a modest diagnostic capability built into the system for calibrating and checking the linearity of the ADCs. This is done through a "test-level" input that injects a charge into each amplifier just as a hit on a wire would in normal operation. We would like to retain this feature and enhance it to allow alternate wires to be selected and to make it more convenient to take "calibration" data out-of-spill or at start of a run.